Pre-Operational Testing Plan
40 CFR 146.87

Wabash CCS Project

Facility Information

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Well location:	Clinton, Vermillion, Indiana 39º 37’ 27.88” N, 87º 29’ 19.17” W

As per 40 CFR § 146.87:

> “During the drilling and construction of a Class VI injection well, the owner or operator must run appropriate logs, surveys and tests to determine or verify the depth, thickness, porosity, permeability, and lithology of, and the salinity of any formation fluids in all relevant geologic formations to ensure conformance with the injection well construction requirements under § 146.86 and to establish accurate baseline data against which future measurements may be compared.”

The following Pre-Operational Testing Plan describes how the requirements of 40 CFR 146.87 and 40 CFR 146.86 will be fulfilled.

Wabash Carbon Services (WCS) will be constructing a new well, WVCCS1, for the injection of CO2 into the Potosi formation of the Illinois Basin at ~4,500 feet MD (3,950 TVDss). Prior to this construction WCS has completed the drilling and investigation of stratigraphic test well, Wabash#1 ~7.2 miles to the south east of the WCSS1 site. Wabash#1 included investigation of the geologic column to a depth of ~8,730 feet MD (8,180 TVDss). Data acquired during drilling and testing from Wabash#1 will be used for comparison purposes while interpreting the data that will be obtained during the drilling and completion of WVCCS1.

During the drilling of WVCCS1, a qualified Mud Logging company will capture samples at a frequency adequate to allow the identification of the formation tops. This information in combination with data collected during the drilling of the Wabash#1 stratigraphic test well will help determine the setting depths for the different casing sections.

The pre-operational testing will be performed in sequence with the well construction activities. As each portion of the well is constructed, a different suite of tests will be performed based on the bore hole conditions (open hole vs cased hole). This plan is broken into sections that will cover each major portion of the injection well and testing associated with each major section. Table 1 provides the primary sections of the well along with estimated depths. The actual depths will be determined during the drilling operations based upon input from the mud log, geologist’s inputs, and surrounding well data.

Table 1 Major Well Sections/Casing Details

Casing String	Casing Depth (MD feet)	Borehole Diameter (inches)	Casing Diameter (OD-inches)	Wall Thickness (inches)	Casing Material	String Weight
Conductor	0-100	30	24	1.094	H40	15,930
Surface	0-350	20	16	.495	J55	29,400
Intermediate	0-~3,400	14 ¾	10 ¾	.350	J55	137,700
Long String (Carbon)	0-~3,200	9 1/2	7 5/8	.75	N80	147,840
Long String (Chrome)	~3,200-~5,400	9 1/2	7 5/8	.75	Chrome Alloy	

Conductor

The 30 inch bore hole for the conductor will be drilled via auger to a depth of ~100 feet.. Once the bore is established, the 24-inch conductor will be set and cemented to surface. Due to the shallow nature of the conductor section no pre-operational testing is proposed. Industry standards for cement setting time will be followed.

Surface Section

Surface casing will be set from 0 ft to 350 feet in a 20 inch bore hole to ensure coverage of potential coal and groundwater. The bore hole will be drilled using a conventional water-based mud (WBM) system. Due to the shallow nature of the surface casing no open hole testing is proposed. Table 2 shows all testing planned for the Surface Casing Section after the casing is installed and cemented.

Table 2 Surface Section Cased Hole Testing

Test Performed	Purpose/Comments
Cement Bond Log (CBL) or Ultrasonic Imaging Tool (USIT)	Cement Integrity
Leak Off Test (LOT)	Surface casing shoe and cement integrity
Pressure Test to ~2500-3000 PSI	Casing Integrity

Intermediate Section

The intermediate section will be set from 350 ft to ~3,400 ft in a 14 ¾ bore hole. The bore hole will be drilled using a conventional WBM system. During drilling operations mud logging of the cuttings return will be performed to provide information to the drilling crew concerning the formation tops and relevant depths. This information will also be used to correlate open hole logging results with other reference wells. A mud logging report will be developed and updated daily.

Directional surveys will be performed at a minimum of every 1000 ft. If site conditions and equipment availability allow more frequent surveys will be performed employing a down hole inclination device (FloDrift or equivalent) to maintain a vertical deviation of less than 5 degrees.

During drilling of the bore whole core samples will be gathered from the Maquoketa Shale at approximately 2600 feet MD (2050 TVDss) and the Shakopee section of the Knox Dolomite Group at

approximately 3,354 feet MD (2,800 TVDss). These core samples will be used to verify the verify lithological properties of the formations overlaying the injection zone and the adequacy of the Maquoketa Shale as the primary seal.

Upon completion of the intermediate bore hole a full suite of open hole logs will be performed. Table 2 shows all testing planned for the open hole of the intermediate section.

Table 3 Intermediate Section Open Hole Testing

Log Performed	Purpose/Comments
Temperature Log	Formation Temperature Profile
1-Arm and 4-Arm Caliper	Bore Hole Diameter/Volume/Condition
Directional Survey	Bore Hole Verticality
Induction	• Characterize basic geology (lithology, mineralogy, porosity, permeability)
Neutron	
Density	
Gamma Ray	
Microlog	
Spontaneous Potential	
Mud Resistivity	
Natural Gamma Ray Spectroscopy	• Enhanced characterization of geologic and geomechanical properties that control injectivity and confining zone/seal integrity • Dipole Sonic log will also provide data to calibrate surface seismic
Elemental Spectroscopy	
Formation Micro Imager (FMI)	
Magnetic Resonance	
Dipole Sonic	
Vertical Seismic Profile (VSP)	• Provide formation depth data and allow refinement of existing 2D and future 3D seismic testing

After completion of the open hole logging the intermediate casing will be set and cemented. The intermediate casing will be set from 0 ft - ~3,400 ft. After completion of the cementing integrity tests will be performed to ensure the protection of USDWs is maintained. Table 4 includes the testing planned for the intermediate section after casing.

Table 4 Intermediate Section Cased Hole Testing

Test Performed	Purpose/Comments
Concrete Bond Log (CBL) or Ultrasonic Imaging Tool (USIT)	Cement Integrity
Leak Off Test (LOT)	Surface casing shoe and cement integrity
Pressure Test to ~2500-3000 PSI	Casing Integrity
Temperature Log	Determine natural geothermal gradient outside well for comparison to future temperature logs for external mechanical integrity evaluations

Long String Section

The long string section will be from ~3,400 ft – ~5,400 ft. The bottom of the long string section will be set ~150 feet into the Eau Claire formation. Setting the long string casing into the Eau Claire will provide a solid foundation for the well construction. This also allows for full logging of the Potosi formation after

completion of the bore hole drilling activities. During drilling operations mud logging of the cuttings return will be performed to provide information to the drilling crew concerning the formation tops and relevant depths. This information will also be used to correlate open hole logging results with other reference wells. A mud logging report will be developed and updated daily.

Directional surveys will be performed at a minimum of every 1000 ft. If site conditions and equipment availability allow more frequent surveys will be performed employing a down hole inclination device (FloDrift or equivalent) to maintain a vertical deviation of less than 5 degrees.

During drilling operations whole core samples of the Potosi formation will be collected. The target depths for the core sample will be based upon information collected from the Wabash#1 stratigraphic test well. Core intervals will overlap the highly vugular zones that are the targets for injection between ~ 4,500 - ~4,700 ft.

Upon completion of the long section bore hole a full suite of open hole logs will be performed. Table 5 shows all testing planned for the open hole of the intermediate section

Table 5 Long String Open Hole Testing

Log Performed	Purpose/Comments
Temperature Log	Formation Temperature Profile
1-Arm and 4-Arm Caliper	Bore Hole Diameter/Volume/Condition
Directional Survey	Bore Hole Verticality
Induction	• Characterize basic geology (lithology, mineralogy, porosity, permeability)
Neutron	
Density	
Gamma Ray	
Microlog	
Spontaneous Potential	
Mud Resistivity	
Natural Gamma Ray Spectroscopy	• Enhanced characterization of geologic and geomechanical properties that control injectivity and confining zone/seal integrity • Dipole Sonic log will also provide data to calibrate surface seismic
Elemental Spectroscopy	
Formation Micro Imager (FMI)	
Magnetic Resonance	
Dipole Sonic	
Quantitative ELAN	
Vertical Seismic Profile (VSP)	• Provide formation depth data and allow refinement of existing 2D and future 3D seismic testing

The hydraulic fracture gradient will be measured in open hole right after drilling, and before casing is run. The test is called a "mini-frac" and will be performed with the Modular Dynamic Testing (MDT) tool. The configuration is to go in with the tool consisting of a pair of inflatable packers, ~3 feet apart. At the interval to be tested, the packers are inflated by pumping wellbore fluid into the packers, sealing them against the formation. At this point, wellbore fluid is then pumped between the packers against the formation. Real-time monitoring of the pressure is done at surface. The pressure is slowly raised until the rock breaks, providing a direct measurement of the fracture pressure of the formation. The pressure is then allowed to bleed off to show the closure pressure. The cycle is repeated at this point several times to measure the fracture extension pressure and repeated closure pressure measurements. After this, the

packers are deflated, and the tool can be moved to a new spot in the sealing formation for a repeat of the measurements. A limitation would be that the pump cannot build up pressure faster than the reservoir will take the fluid. This will be determined at the time the logs are run.

After completion of the open hole logging the long string casing will be set and cemented. The long string casing will be set from 0 ft - ~5,400 ft. After completion of the cementing integrity tests will be performed to ensure the protection of USDWs is maintained. Table 6 includes the testing planned for the intermediate section after casing.

Table 6 Long String Cased Hole Testing

Test Performed	Purpose/Comments
Concrete Bond Log (CBL) or Ultrasonic Imaging Tool (USIT)	Cement Integrity
Leak Off Test (LOT)	Surface casing shoe and cement integrity
Pressure Test to ~2500-3000 PSI	Casing Integrity
Temperature Log	Determine natural geothermal gradient outside well for comparison to future temperature logs for external mechanical integrity evaluations
Baseline casing inspection	Obtain baseline assessment of casing condition through confining zone for comparison to future casing inspection logs

After all casing is set the lowermost interval will be perforated to allow for injection into the desired section of the Potosi formation. After the casing is perforated a series of injectivity tests and formation fluid tests will be performed. Table 7 includes the testing planned before the commencement of operation of the injection well.

Table 7 Formation Testing

Test Performed	Purpose/Comments
Fluid Temperature	Determine natural geothermal gradient outside well for comparison to future temperature logs for external mechanical integrity evaluations
Fluid pH	Provide baseline of formation pH for reference to future samples
Fluid Conductivity	Provide baseline of formation Conductivity for reference to future samples
Reservoir Native Pressure	Provide baseline of formation pressure for comparison during injection activities and CO2 plume monitoring
Static Fluid Level	Determination of bottomhole pressure
Pressure Fall Off Test	Verification of connectivity of sequestration field
Step Rate Test	Determination of Fracture Pressure, Frac Gradient and highest allowable injection pressure
Injectivity Test	Verification of the injectivity rates used in the Plume and AOR simulations

Data Analysis and Reporting

WCS will submit to the Director a detailed report prepared by a log analyst that includes: Well log analyses (including well logs), core analyses, and formation fluid sample information.